

Based Upon: PCT/EP2004/001084

REMARKS

Applicants respectfully request entry of the above Preliminary Amendment to place this U.S. Patent Application in better form for examination and prosecution before the U.S. Patent and Trademark Office.

The claims have been amended to eliminate multiple dependent claims and to more definitely and fully claim the subject matter of Applicants' invention. Applicants urge that the above Preliminary Amendment introduces no new matter into this U.S. Patent Application.

Applicants sincerely believe that this U.S. Patent Application is now in condition for examination and prosecution before the U.S. Patent and Trademark Office.

Respectfully submitted,



Douglas H. Pauley
Registration No. 33,295

Pauley Petersen & Erickson
2800 West Higgins Road; Suite 365
Hoffman Estates, Illinois 60195
TEL (847) 490-1400
FAX (847) 490-1403

[Discussion of Related Art

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LIQUID COOLING SYSTEM

BACKGROUND OF THE INVENTION Field of the Invention

[The] ^{This} invention relates to a liquid cooling system having several cooling units, which are individually assigned to electronic component groups, which are housed in a rack or switchgear cabinet and ^{which also} are to be cooled, and ^{furthermore} having a monitoring and control arrangement for monitoring the cooling temperature.

[Such a] ^A liquid cooling system is disclosed in ^{German Patent Reference} DE 196 09 651 C2 in connection with a switchgear cabinet air-conditioning arrangement. In this case, the liquid cooling system is designed, for example, as a cooling device or cooling unit with an air/water heat exchanger and represents a component of the entire air-conditioning arrangement, which is monitored and controlled or regulated by ^{with} means of a higher-order monitoring and control arrangement. It is possible ^{provide} by means of the cooling system, together with the monitoring and control arrangement, to realize varied control concepts of the air-conditioning arrangement, depending on its type of employment or the wishes of the user. [In this connection] ^{Thus} there is also ^a the possibility of locally cooling individual electronic component groups, for which purpose fan units, which ^{are} have been assigned to them, are triggered. However, if a rack or a switchgear cabinet ^{has} is equipped with a multitude of electronic component groups with high computer output, very large amounts of heat can collect, ^{particularly} in particular in the area of the computer units, which are difficult to remove even with such a cooling arrangement.

^{taught by PCT International Publication} A switchgear cabinet monitoring and control system is ^(described in) WO 97/34345, into which an air-conditioning device with a cooling apparatus and fans, as well as heat exchangers, ^{are} have been integrated ^[inter alia]. A cooling concept for removing heat in the vicinity of individual component groups is not ^{further} described in this publication.

SUMMARY OF THE INVENTION

^{One} [The] object of ^{this} [the] invention is [based on making available] ^{to provide} a liquid cooling system of the type mentioned [at the outset, by means of which] cooling can be dependably provided, in particular in case of a large packing density of electronic component groups in the rack or switchgear cabinet, and heat damage to the electronic component groups can be prevented.

This object is ^{achieved with} [attained by means of the characteristics of claim 1. In this connection it is provided for the] cooling units [to be] embodied as liquid cooling units and [to be] connected via branch points to a common central liquid line system integrated into the rack or switchgear cabinet, ^{The} and that [the] control and monitoring arrangement is embodied for monitoring the cooling temperature in the central liquid line system and for emitting an error signal when a predetermined or predeterminable threshold temperature in a liquid return branch is exceeded, ^{when} or a predetermined or predeterminable threshold temperature difference between a temperature in an inlet branch and a temperature in the return branch is exceeded, or when the liquid flow falls below a predetermined or predeterminable threshold value.

The electronic component groups are dependably cooled with a high degree of effectiveness by [means of] the liquid cooling units assigned to them. [In the course of] ^{During} this, excess heating is dependably detected by monitoring the cooling temperature and/or the flow in the central liquid line system and, if required, is taken into consideration in the system by emitting an appropriate error signal, or by appropriate processing.

Damage to the electronic component groups to be cooled is prevented dependably and [by simple means in that] ^{simply when} the error signal is used for triggering an alarm and/or [for] switching off a common electric current supply for all electronic component groups.

Particularly effective cooling is achieved ^{if} ~~in that~~ the cooling units have cooling elements through which coolant flows, and which are thermally connected to temperature-sensitive, heat-producing electronic components.

A well arranged construction with simple connecting possibilities is obtained

^{because} ~~in that~~ the central liquid line system has a line unit ^{provided} with an inlet conduit and a return conduit, which is ^{has} mounted vertically ^{oriented} in the rack or switchgear cabinet and ^{is} provided over its length ^{with} coupling means, preferably equidistantly arranged, for forming branch points.

The steps, wherein a section of the central liquid line system extending in the rack or switchgear cabinet is attached to a vertical frame leg, to at least one mounting rail, or to the inside of a lining element, contribute to a simple construction with easy mounting options.

In this connection advantageous arrangement possibilities arise ^{because} ~~in that~~ a receptacle, open over ^a ~~its~~ length toward the interior of the rack or switchgear cabinet, is integrated on or into the frame leg, into which the section of the central liquid line system is inserted.

Different ^{embodiments} ~~embodiment variations~~ for effective cooling ^{have} ~~consist in that~~ the central liquid line system ^{is} connected to an air/liquid heat exchanger and/or a liquid/liquid heat exchanger, and ^{furthermore in that} the liquid/liquid heat exchanger is connected to a recooling arrangement.

BRIEF DESCRIPTION OF THE DRAWINGS

^{This} ~~The~~ invention ^{will be explained in greater detail in} ^{is} ~~what follows by means~~ of exemplary embodiments and by making reference to the drawings.

^{wherein the} ~~The~~ drawing shows a schematic representation of an example of ^a ~~the~~ structure of a liquid cooling system for cooling a multitude of electronic component groups ^{installed}

DESCRIPTION OF PREFERRED EMBODIMENTS

The electronic component groups 1 in a rack 2, each of which has at least one central processing unit (CPU) 1.1 of high computing output as the main heat producer in a housing containing the electronic components group 1.

For cooling the electronic component group 1, in particular by the processor units or computer units 1.1 embodied as integrated components, cooling elements 4 of the liquid cooling units, which have been applied in tight heat conducting contact to the component element body, through which the coolant is conducted over as long as a possible path. The liquid cooling units with the cooling elements 4 are connected via respective inlet branch lines and return branch lines by means of respective branch points 5.1 with coupling elements to a vertical section of a central liquid line system 5 extending in the rack. The central liquid line system 5 also has an inlet branch 5.2 and a return branch 5.3 for the coolant, wherein the vertical section arranged in the rack 2, or switchgear cabinet, is preferably designed as a line unit 5.4 with the inlet branch 5.2 and the return branch 5.3.

The line unit 5.4 is connected in its lower area via a further section of the inlet branch 5.2 and the return branch 5.3 to a water/water heat exchanger 6, which is received in an electronic housing 3. A monitoring and control arrangement 9 for the functions of the switchgear cabinet or rack 2 is received in the electronic housing 3 which, inter alia, is also connected to the inlet branch 5.2 and the return branch 5.3 for detecting the temperature of the liquid, or the water, there prevailing there.

A simple recooling unit or a fan arrangement is also conceivable for cooling the liquid.

The water/water heat exchanger 6 is connected via further lines to a recooling arrangement 7, which assures dependable cooling of the coolant and presents, for example, the opportunity of also giving off the created heat outside of the room in which the rack 2 or

the switchgear cabinet with the electronic component groups to be cooled are located, in order to prevent too high a room temperature.

Furthermore, the upper area of the vertical section of the central liquid line system 5 is connected by ^{means of} further lines to an air/water heat exchanger 8 arranged on the rack 2 or switchgear cabinet, by ^{means of} which further cooling is achieved and wherein, with an appropriate design, the general temperature in the area of the component groups, or in the interior of the switchgear cabinet, can also be reduced.

Furthermore, by ^{way of} example, a monitor keyboard unit 10 and a server switch control are arranged in the rack 2 which, however, because of their low heat production, need not be connected to the central liquid line system 5.

If ^{with} by means of temperature sensors or liquid flow monitors the monitoring and control arrangement 9 detects in or at the liquid line system that, for example, the absolute temperature in the return branch 5.3, or a temperature difference between the inlet branch 5.2 and the return branch 5.3 exceeds a predetermined or predeterminable threshold, ^{then} it emits an error signal or an error report, by ^{means of} which a warning light or a warning sound can be switched on, for example, or a display for informing the user can be controlled, ^{and} ^{wherein} this can also be passed on to a remote monitoring station via a network connection. An advantageous step also ^{is} ^{so} consists in that the monitoring and control arrangement 9 is designed ^{in such a way} that, in case of the appearance of an error signal, it switches off a common electrical current supply 1, so that ^{it is assured that} no damage on account of the temperature occurs in this arrangement which, as a rule, is very expensive. Also, a more extensive computer-operated processing of the error signal, and/or the storage in a error memory device for diagnosis or later evaluation can be provided. In this case the monitoring and control arrangement 9 ^{forms} constitutes a higher-order monitoring system, with which still other sensor

signals can be received and monitored, as well as various actuators of the cooling system can be controlled and regulated, such as explained in greater detail in ^{German Patent Reference} [the publications] DE 196 09 651 C2 and ^{PCT International Publication} WO 97/34345 [mentioned at the outset].

The vertical section of the central liquid line system 5 arranged in the rack or switchgear cabinet ⁵ is preferably embodied as a line unit with an inlet conduit and a return conduit, and can be separately arranged in the interior of the rack 2 or the switchgear cabinet, for example on a vertical frame leg, on mounting rails or on the inside of a lining element. An embodiment is also particularly advantageous, wherein a vertical frame leg has a U-shaped receptacle, open over its length toward the interior of the rack 2 or switchgear cabinet, into which the line unit can be inserted later and fixed in place, for example snapped in ^{place}. Connecting points with coupling elements for connecting the branch lines leading to the electronic component groups 2 are provided at regular spacings over the length of the line unit 5.4.